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EFFECTS OF Al_2O_3 NANO PARTICLES ON RHEOLOGICAL PROPERTIES OF TRANSESTERIFIED RAPESEED OIL

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Abstract

Environmental concerns in fossil fuel depletion intensified the search for alternate fuel from renewable resources. The focus of this study is to investigate influence of Al_2O_3 and nano particles on rheological properties of transesterified rapeseed oil. The crude rapeseed oil was purified, transesterified and nanoparticles were dispersed in the transesterified oil with concentration ranging from 0.2% to 1.0% in 0.2% interval. X-ray fluorescence (XRF) was used to study the chemical composition, X-ray diffraction (XRD) was used to study mineral properties and scanning electron microscopy (SEM) was used to observe the surface morphology of the nanoparticles. The viscosity of the transesterified rapeseed nanofluid oil was studied. The viscosity of the transesterified oil decreases with the dispersion of Al_2O_3 nanoparticles. It was found out among other things that small amount of 0.2% of Al_2O_3 nanoparticles produces optimal rheological properties. This is due to the interaction of triglyceride with methanol through alcoholysis reaction to produce fatty acid methyl ester (biodiesel), the molecular chain is reduced.

Key words; Al_2O_3, Nanoparticles, Rapeseed oil, Viscosity, SEM

Introduction

The exploration of other energy resources has attracted a lot of consideration due to the increase of worldwide energy demands, green and political worries on atmosphere contamination originated by the ignition of petroleum oils [1-15]. Biodiesel has received great awareness worldwide as a source of substitute fuel owing to its typical properties, such as non-toxicity, biodegradability, essentially free sulfur and less release of CO gas [2]. Moreover, biodiesel has a higher flash point, better cetane number and less exhaust emission [3]. Recently, biodiesel has been economically possible in the fuel market as a fossil-diesel alternative. In fact, it could be applied to the current compression ignition vehicle engines with no alteration [4]. Yet, the raw material price has been considered as a big percent of the direct biodiesel manufacturing cost [5]. Hence, the low cost acidic oil feedstocks are considered as the best sources which contribute in decreasing the industry budget of the biodiesel.

Biodiesel is gradually gaining acceptance in the market as an environmentally friendly fuel and the demand is expected to increase sharply as an alternative renewable energy source in the near future. Biodiesel fuel is mono alkyl ester derived from vegetable or animal and it can be blended with diesel fuel which has characteristics similar to diesel fuel and has lower exhaust emissions [16–20]. On the other hand, the main drawbacks of vegetable oil have to overcome due to the high viscosity and low volatility which will cause a poor combustion in diesel engines. Transesterification is the process successfully employed to reduce the viscosity of biodiesel and improve the other characteristics [6]. Nanoparticles additives when used are expected to further enhance the rheological properties of the rapeseed oil.

The addition of nanoparticles into transterified oil is expected to enhance significantly the oxidative stability, reduces the friction coefficient and increases the load-bearing capacity of the friction parts in mechanical systems. A variety of mechanisms have been proposed to explain the lubrication enhancement of the nanoparticle suspended lubricating oil (i.e., nano-oil), including the ball bearing effect [7], protective film mending effect and polishing effect. These mechanisms can be mainly classified into two groups. The first is the direct effect of the nanoparticles on lubrication enhancement. The nanoparticles suspended in lubricating oil play the role of ball bearings between the friction surfaces. In addition, they also make a protective film to some extent by coating the rough friction surfaces [8]. The other is the secondary effect of the presence of nanoparticles on surface enhancement. The nanoparticles deposit on the friction surface and compensate for the loss of mass, which is known as mending effect. And also the roughness of the lubricating surface is reduced by nanoparticle-assisted abrasion, which is known as a polishing effect.

However, paper wishes to investigate the effects of Al_2O_3 nanoparticles on rheological properties of transesterified biodiesel rapeseed oil.

Methodology

X-ray Fluorescence (XRF)

The nannoparticles was subjected to the XRF analysis. The machine used for the analysis was XRF Bruker S4 Pioneer which was operated at 60 KV.

Scanning Electron Microscopy (SEM)

The surface morphology of the titanium oxides was observed using multipurpose Scanning Electron Microscope [SEM] PHENOM PROXMVE016477830, done at Umaru Musa Yaraduwa University Katsina. Small amount of the sample powder was poured on the carbon tape which is attached to the holder. Then the excess powder was blown off with air gun to ensure that only small pieces of the powder remain on the tape. After that, it was put into in the SEM chamber for analysis. The SEM machine was operated at 10kV. A magnification of X350 was used to capture the photo of the sample.

Sample Purification

The rapeseed oil was purified through the following procedure; 200 ml of the rapeseed oil was measured using measuring cylinder; the oil was pre-heated to 70 ^{o}C using hot magnet stirrer with thermometer. Then 1.5 ml citric acid was measured and added to the heated oil sample and continuously heated and stirred for 15 minutes at 70 ^{o}C.4 ml of 8 % NaOH (by dissolving 8 g NaOH in 100 ml of distilled water) was then be added to the oil and continuously heated and stirred for 15 minutes at 70 ^{o}C. The mixture was then transferred to the vacuum oven where it was heated at 85 ^{o}C for 30 minutes. Then the mixture was taken back to hot magnetic stirrer and heated to 70 ^{o}C after which a 2 g 0f silicone reagent was added while it was being heated and stirred for 30 minutes. Then the temperature was increased to 85 ^{o}C and 4 g of activated carbon was added to each 100 ml of the oil sample, heated and stirred for 30 munites. Then the mixture was separated using filter paper.

Trans-esterification

60g of the crude rapeseed oil was measured in 250ml of conical flask and was heated and stirred to a temperature of 60-65℃ on a hot magnetic stirrer plate, 0.6g of NaOH was measured using the electronic weight machine and allowed to dissolve in 21ml of methanol and then allowed to heat for 60 minutes with the stirrer on the hot magnetic plate. After 60 minute of uniform stirring and heating on the hot magnetic plate maintaining a temperature of 65℃, it was then poured into the separating funnel through a glass funnel. The mixture was allowed to cool for about 40 minute. Afterwards, it was observed that it separated into two liquid layers. The upper layer is the biodiesel and the lower layer is triglycrol fatty acid. The biodiesel was then separated from its byproduct.

Nano-fluids Preparation

The Al_2O_3 Nano-particles powder was purchased from Sky Spring Nanomaterials, Inc., U. S. A, the size of the nano-particles is 10-20nm and the surface was modified with Epoxy Group and its dispersible as mentioned by the company. Nano-fluids are prepared by two step process. The volume concentration of 0.2%, 0.4%, 0.8% and 1.0% of powdered nano-particles and purified palm oil was made respectively. To make the nano-particles more stable and remain more dispersed, each sample was stirred for 3-4 hours using magnetic stirrer, then the samples were taken for analysis.

Samples measurement Viscosity

Viscosity was measured using Brookfield viscometer in a speed range of 50 rpm with spindle size of 2 since a small quantity of the sample is to be measured. The following are the detailed procedure for viscosity measurement. The sample was poured into a beaker, the spindle was fixed and the machine was started, the angular speed was selected on the viscometer and the viscosity was read and recorded the same procedure was repeated for the purified rapeseed.

Results and Discussions

Figure 1 shows the scanning electron microscope of the Al_2O_3 nanoparticle. It can be seen from the picture that the morphology of the oxide is so white of oval in shape with a porous structure.

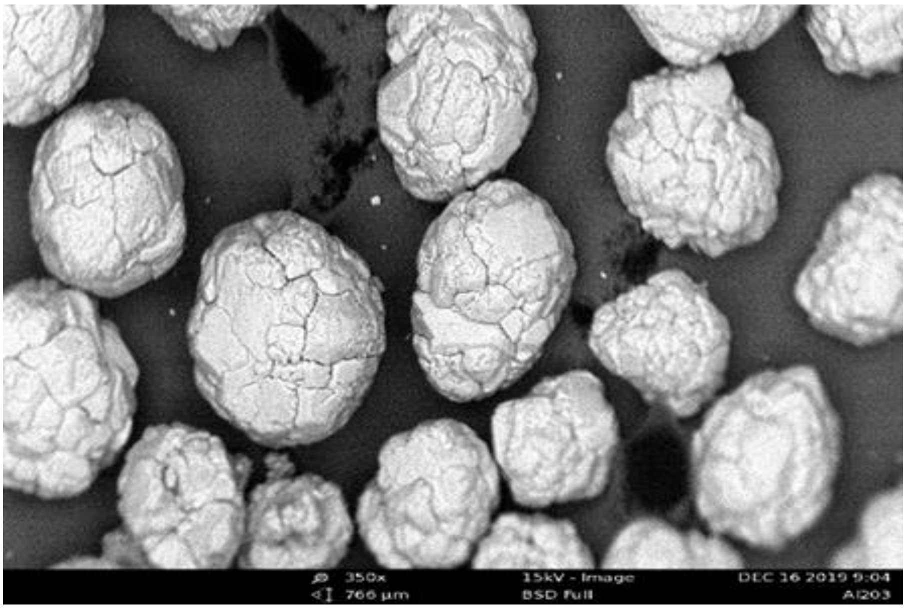

Figure 1: SEM of Al_2O_3

The XRF of the Al_2O_3 was observed at Umaru Musa Yaraduwa University Katsina, in order to find out the percentage concentration of the oxide composed in the sample of nano particle used to carry out the research and the result is summarized in table 1 below. It could be seen that from the table Al_2O_3 (94.844) has the highest percentage in the sample followed by Cl (1.085)

Table 1: Chemical Constituents

Element	Al_2O_3	Cl	SiO_2	MgO	Na_2O	**S**	CaO	Fe_2O_3	Ni_2O	Ga_2O_3	LOI
Con (%)	94.844	1.085	0.9574	0.612	0.415	0.1061	0.06372	0.03766	0.01251	0.01129	1.855

Viscosity is a measure of the internal friction or resistance of an oil to flow. As the temperature of oil is increased, its viscosity decreases (Figure 2) and it is therefore able to flow more readily. Viscosity is measured on several different scales. The viscosity of transesterified biodiesels dropped significantly; there was a decrease of viscosity. Due to the interaction of triglyceride with methanol through alcoholysis reaction to produce fatty acid methyl ester (biodiesel), the molecular chain is reduced. The relative molecular weight of biodiesel is lower than that of the virgin vegetable oil, and the higher increase in pour point of biodiesel may relate to the fact that biodiesel had a linear chain and, therefore, is easily crystallized [20]. But vegetable oil has longer branch chain and more steric effect. The cold filter point of biodiesel is lower than that of the corresponding virgin vegetable oil. There is a strong interaction between flow properties of biodiesel and its composition. The melting point of fatty acid methyl ester increases with the increasing of carbon chain and decreasing of the degree of unsaturation. For the same carbon chain number, the melting point of the saturated fatty acid methyl ester is higher than that of the unsaturated fatty acid m d fatty acid methyl ester is higher than that of the unsaturated fatty acid methyl ester.

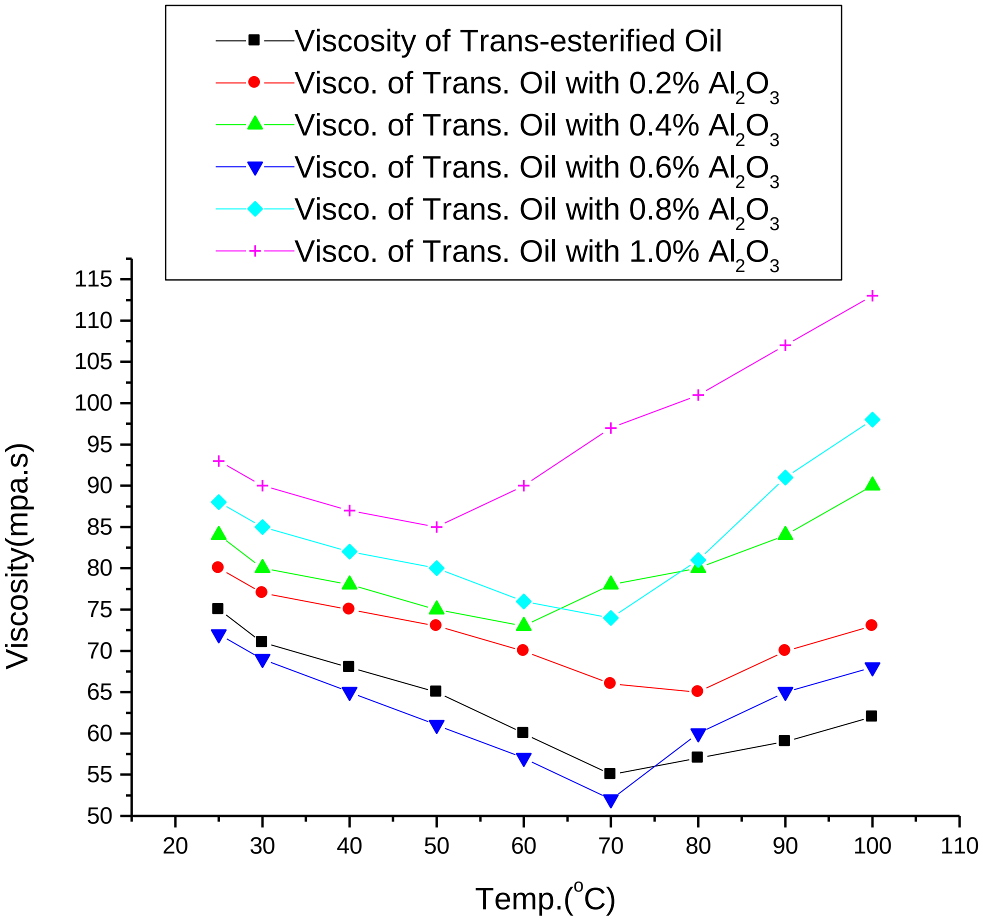

Figure 2 Viscosity Versus Temperature of Rapeseed Oil

The viscosity of transesterified rapeseed oil in this study was within the given standards. The viscosity was less for transesterified from rapeseed oil and its blends than for the crude alone. It has been reported by Lin and Li *et al.*, [20] that the larger proportions of saturated fatty acids with longer carbon chains cause viscosity to increase. The methyl ester which contained highly saturated fatty acids appeared to have greater viscosity. Refaat *et al.* [21] founded that viscosities for the animal fat-derived fatty acid methyl ester, in general, were slightly higher than that for the soy-based esters but were within the specified limit. Also reported that biodiesel fuels derived from used crude oils tend to possess higher viscosity than those from most transesterified vegetable oils, owing to their higher content of trans FA and saturated. But it was not observed a linear increase with the amount of nanoparticles ratio in the feedstock. As a result, it can be said that the viscosity was positively influenced when the rapeseed oil was dispersed with nanoparticles for the biodiesel production.

Conclusion

The morphology of the 0.2% Al_2O_3 nanoparticles is so white of oval in shape with a porous structure. The XRF result of the Al_2O_3 nanoparticles constitute 94.84% percentage in the sample followed by Cl with 1.08%. The rheological properties of transesterified rapeseed oil was studied as function of temperature and the addition of nano particles. The relationship between viscosity and the addition of Al_2O_3 nano particles in the transesterified rapeseed oil shows that the viscosity decreases as the of transesterified rapeseed increases in the sample. The addition of 0.2% Al_2O_3 nano particles in the transesterified rapeseed oil exhibit higher rheological properties. This is as result of the interaction of triglyceride with methanol through alcoholysis reaction to produce fatty acid methyl ester (biodiesel), the molecular chain is reduced. Similarly, the interaction of nanoparticles and triglyceride with methanol through alcoholysis reaction to produce fatty acid methyl ester (biodiesel), the molecular chain is reduced. It could therefore, be concluded that the dispersing 0.2% Al_2O_3 nano particles in the transesterified rapeseed yield higher rheological properties.

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References

[1] Alhassan, F. H., Rashid, U., & Taufiq-Yap, Y. H. (2015). Synthesis of waste cooking oil-based biodiesel via effectual recyclable bi-functional Fe2O3MnOSO42−/ZrO2 nanoparticle solid catalyst. *Fuel*, *142*, 38-45.

[2] Ong, H. C., Mahlia, T. M. I., Masjuki, H. H., & Norhasyima, R. S. (2011). Comparison of palm oil, Jatropha curcas and Calophyllum inophyllum for biodiesel: a review. *Renewable and Sustainable Energy Reviews*, *15*(8), 3501-3515.

[3] Jamo, H. U., Abdu, S., Yusuf, B., & Auwalu, I. A. (2019). PREPARATION OF BIODIESEL FROM SOYBEAN OIL BY TRANSESTERIFICATION. *Journal Homepage: http://ijmr. net. in*, *6*(06).

[4] Jamo, H. U., Aliyu, A., & Yusuf, B. (2019). Influence of Na_2CO_3 Nanoparticles on the Physical Properties of Castor Oil. *Journal Homepage: http://ijmr. net. in*, *6*(06).

[5] Jamo, H. U., Aliyu, R., & Yusuf, B. (2019). EFFECTS OF ADDITION OF CeO_2 NANO PARTICLES ON THE PHYSICAL PROPERTIES OF JATROPHA OIL. *Journal Homepage: http://ijmr. net. in*, *6*(05).

[6] Jamo, H. U., Umar, I. D., Yusuf, B., & Auwalu, I. A. (2019). ENHANCEMENT OF PHYSICAL PROPERTIES OF BIODIESEL EXTRACTED FROM PALM OIL BY THE

ADDITION MgO NANO PARTICLES. *Journal Homepage: http://ijmr. net. in*, *6*(05).

[7] Mendecka, B., Lombardi, L., & Kozioł, J. (2020). Probabilistic multi-criteria analysis for evaluation of biodiesel production technologies from used cooking oil. *Renewable Energy*, *147*, 2542-2553.

[8] Liu, Y., Zhang, P., Fan, M., & Jiang, P. (2016). Biodiesel production from soybean oil catalyzed by magnetic nanoparticle $MgFe_2O_4$@ CaO. *Fuel*, *164*, 314-321.

[9] Shaafi, T., & Velraj, R. (2015). Influence of alumina nanoparticles, ethanol and isopropanol blend as additive with diesel–soybean biodiesel blend fuel: Combustion, engine performance and emissions. *Renewable Energy*, *80*, 655-663.

[10] Abdullah, Rose Fadzilah, et al. "Potential heterogeneous nano-catalyst via integrating hydrothermal carbonization for biodiesel production using waste cooking oil." *Chemosphere* 286 (2022): 131913.

[11] Panchal, Balaji, et al. "The current state applications of ethyl carbonate with ionic liquid in sustainable biodiesel production: A review." *Renewable Energy* 181 (2022): 341-354.

[12] Jung H, Kittelson DB, Zachariah MR. The influence of a cerium additive on ultrafine diesel particle emissions and kinetics of oxidation. Combust Flame 2005;142:276e88.

[13]] Yusuf, Abdulfatah Abdu, Freddie L. Inambao, and Jeffrey Dankwa Ampah. "Evaluation of biodiesel on speciated PM2. 5, organic compound, ultrafine particle and gaseous emissions from a low-speed EPA Tier II marine diesel engine coupled with DPF, DEP and SCR filter at various loads." *Energy* 239 (2022): 121837.

[14] Chu, R., Hu, D., Zhu, L., Li, S., Yin, Z., & Yu, Y. (2022). Recycling spent water from microalgae harvesting by fungal pellets to re-cultivate Chlorella vulgaris under different nutrient loads for biodiesel production. *Bioresource Technology*, *344*, 126227.

[15] Wang, X., Dou, P., Zhao, P., Zhao, C., Ding, Y. and Xu, P., 2009. Immobilization of lipases onto magnetic Fe3O4 nanoparticles for application in biodiesel production. ChemSusChem: Chemistry & Sustainability Energy & Materials, 2(10), pp.947-950.

[16] Mirhashemi, F. S., & Sadrnia, H. (2020). NO_X emissions of compression ignition engines fueled with various biodiesel blends: A review. *Journal of the Energy Institute, 93*(1), 129-151.

[17] Shanmugam, S., Hari, A., Pandey, A., Mathimani, T., Felix, L., & Pugazhendhi, A. (2020). Comprehensive review on the application of inorganic and organic nanoparticles for enhancing biohydrogen production. *Fuel*, *270*, 117453.

[18] Janakiraman, S., Lakshmanan, T., Chandran, V., & Subramani, L. (2020). Comparative behavior of various nano additives in a DIESEL engine powered by novel Garcinia gummi-gutta biodiesel. *Journal of Cleaner Production*, *245*, 118940.

[19] Hosseinzadeh-Bandbafha, H., Tabatabaei, M., Aghbashlo, M., Khanali, M., Khalife, E., Shojaei, T. R., & Mohammadi, P. (2020). Consolidating emission indices of a diesel engine powered by carbon nanoparticle-doped diesel/biodiesel emulsion fuels using life cycle assessment

framework. *Fuel*, *267*, 117296.

[20] Nematian, T., Salehi, Z., & Shakeri, A. (2020). Conversion of bio-oil extracted from Chlorella vulgaris micro algae to biodiesel via modified superparamagnetic nano-biocatalyst. *Renewable Energy*, *146*, 1796-1804.

[21] Li, H., Shen, B. X., & Yu, P. H. (2010). The cold temperature fluidities of biodiesel prepared from vegetable oil. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, *32*(13), 1195-1200.

[22] Refaat, A. A. (2009). Correlation between the chemical structure of biodiesel and its physical properties. *International Journal of Environmental Science & Technology*, *6*(4), 677-694.